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DESILICATED GRANITIC PEGMATITES¹.

BY SAMUEL G. GORDON.

The granitic pegmatites are among the most interesting mineral assemblages known to the mineralogist, containing as they frequently do so many rare minerals. The present paper describes an abnormal group of granitic pegmatites, composed either of plagioclase, usually albite, alone (albitite); of plagioclase and corundum (plumasite); or largely of corundum; all of which occur exclusively in peridotites or their altered equivalents. The conclusion has been reached that they owe their peculiarities to the reactions which occurred between the original pegmatitic solutions and the peridotite or serpentine into which these solutions were intruded. Such an origin has been demonstrated for the plumasite of South Africa by Du Toit²; a study of the albitites of Pennsylvania and Maryland indicates a similar genetic history; and the corundum deposits of Pelham and Chester, Massachusetts, of western North Carolina, and of Georgia present analogies which show them to belong in this group.

PREVIOUS WORK.

Albitite.

CALIFORNIA: The name albitite was given by Turner³ in 1896 to an albite rock occurring as dikes in serpentine in the Grizzly Hill area, about Meadow Valley, and near Big Bar Hill, Plumas County, California. The albitite dikes were composed of large grains of albite with marked cleavage, and showing occasionally a twin lamella.

Previous to this, Palache⁴ had described a soda amphibole (cros-

¹ The writer is indebted to Dr. Edgar T. Wherry and Dr. N. L. Bowen for a critical examination of this paper. The Pennsylvania and Maryland albitite were studied during the summer of 1920. An account of the minerals of the district will appear shortly in *The American Mineralogist*, and a description of the chromite deposits in a later paper in the *PROCEEDINGS* of this Academy.

² *Trans. Geol. Soc. S. Africa*, 21: 53-73, 1919 (see abstract below).

³ *Am. Geol.* 17: 375-388, 1896; *Fourteenth Ann. Rep. U. S. Geol. Surv.*, 1892-93, (1894) 477; *U. S. Geol. Surv. Folio* 43, 1898.

⁴ Charles Palache, *Univ. of Calif. Publ., Dept. Geol., Bull.* 1: 181-192, 1894.

site) from a large boulder of white saccharoidal albitite which was found in the bed of a stream at the foot of the Sierras near Berkeley. The boulder contained also veins of actinolite.

FRANCE: In 1900, Lacroix noted the occurrence of albitite dikes in the peridotites of Bellongue (Ariège), France, consisting essentially of albite-oligoclase.⁵

URAL MOUNTAINS: Duparc and Pamfil have described albitite from Koswinsky, in the northern Ural Mountains, where it forms aplitic dikes in dunite.⁶ As in the case of the California and French occurrences no data was given as to the relation of the albitite to the country rock, beyond the fact that it formed intrusives in serpentine or peridotite.

The Russian albitite is associated with a series of related rocks which have been named granulite, gladkaite and plagiaplite.

The granulite is a rock composed essentially of quartz, andesine, and biotite, forming veins in the dunite of Koswinsky.

Gladkaite is a fine grained aplite composed of oligoclase and andesine, with much quartz, some hornblende and biotite, and secondary muscovite and epidote. It forms dikes in the dunite at Gladkai Sopka, and Kamenouchky.

Plagiaplite is an equigranular aplite composed of oligoclase or andesine, with variable amounts of quartz and hornblende, and subordinate muscovite or biotite. This rock forms dikes in the pyroxenites of Koswinsky and Kamenouchky.

This series may represent granitic pegmatites which differ in the degree of desilication which they have undergone. Analyses of them are given by Duparc and Pamfil.

The occurrence of albitic dikes in the serpentines of New South Wales was noted by Benson⁷ who considered them as being genetically related to the peridotites.

Plumasite.

CALIFORNIA: The name plumasite was given by Lawson to an oligoclase-corundum rock forming a fifteen foot dike in a serpentinized peridotite on the lower flank of Spanish Peak, Bidwell Bar quadrangle, Plumas County, California.⁸

⁵ Alfred Lacroix, *Comptes Rendus du VIII Congrès International de Géologie*, 1900: 806-838, Paris, 1901.

⁶ *Bull. Soc. Franc. Min.*, 33: 347-375, 1910.

⁷ *Proc. Linn. Soc. New South Wales*, 38: 691, 1913; *Am. J. Sci.*, (4) 46: 715, 1918.

The plumasite is a coarse allotriomorphic granular aggregate of white oligoclase ($\text{Ab}_{55}\text{An}_{45}$) in which are imbedded pale violet blue idiomorphic crystals of corundum. Scaly films of margarite occur in fractures in the corundum. One hundred feet northwest of the corundiferous portion of the dike, the rock consists of coarse granular plagioclase without corundum, but with occasional nests of a grayish-green fibrous monoclinic amphibole. Twenty-five feet southeast of the corundiferous portion, the dike consists of microcrystalline and porphyritic andesine. An analysis of the oligoclase is given below.

ITALY: In 1903, Lacroix⁹ called attention to the occurrence of plumasite near Mosso Santa Maria, Biella, Italy, from which Gonard¹⁰ had described corundum crystals. An analysis of the oligoclase is given below.

NEW CALEDONIA: Subsequently, Romeu¹¹ noted the occurrence of plumasite in New Caledonia.

TRANSVAAL: The Transvaal corundum deposits have been described by Wagner.¹² South Africa is the leading corundum-producing country at present, the greater part coming from the Zoutspansberg and Pietersburg districts of the Transvaal. Most of the corundum recovered occurs as alluvial crystals or fragments and boulders. The source of the material was found to be a plumasite composed essentially of andesine, ($\text{Ab}_{55}\text{An}_{45}$), greenish biotite and corundum. The corundum occurs in crystals up to 6 inches in length scattered through the plumasite, which, however, may consist wholly of andesine.

NATAL: In 1919, Du Toit¹³ described the plumasite of Natal, with details concerning its relation to the country rock, and mode of origin.

The Natal plumasite forms dikes in the serpentine bodies of the Tugela Valley. The area is underlain by hornblende-schists, granulites, and basic gneisses, riddled with dikes and veins of pegmatite and aplite. In this complex are sills of serpentine, a light gray to dark green fine grained rock composed almost entirely of antigorite, with occasional plates of talc and black particles of

⁸ Univ. of Calif. Publ., Dept. Geol., Bull. 3: 219-229, 1903.

⁹ Bull. Soc. Franc. Min., 26: 147-150, 1903.

¹⁰ Bull. Soc. Franc. Min., 20: 177-181, 1897.

¹¹ Bull. Mus. d'Hist. Nat., 12: 594-596, 1906.

¹² Trans. Geol. Soc. S. Africa, 21: 37-42, 1919.

¹³ Trans. Geol. Soc. S. Africa, 21: 53-73, 1919.

magnetite and chromite. Microscopic study indicates that the original rock was a saxonite composed of predominant enstatite or bronzite.

The plumasite dikes are very irregular in thickness and direction, and are composed of white granular oligoclase on the margins; towards the center corundum makes its appearance with silvery white margarite; in places corundum and margarite may occur to the exclusion of the oligoclase. The composition of the plumasite veins varies considerably, in some places being entirely feldspathic, and elsewhere quite rich in corundum. The oligoclase forms granular aggregates, only one third of which exhibits repeated twinning, although the bulk of the remainder possesses a higher index of refraction than balsam. The corundum forms dark gray, grayish green or bluish crystals, which are frequently sheathed by a thin shell of primary margarite. At times secondary margarite penetrates the basal cleavage plates of the corundum, or forms margaritized individuals with remnants of corundum.

The most interesting plumasite dike pierced a large sill of serpentine flanked below by granulite which was exposed through a vertical range of 150 feet. In the granulite the dike was a normal granitic pegmatite composed of quartz, orthoclase, and subordinate plagioclase, with hardly any biotite, and no corundum. In the serpentine above the dike had contracted in width, lost all its quartz, but now carried corundum.

Du Toit advanced the view that the plumasite owes its genesis to the desilicating action of the serpentine walls upon the originally acid magma constituting the dike. Evidence of reaction between the invading acid magma and its ultrabasic walls is quite evident. Between the plumasite and the serpentine is a contact zone from a few feet to 10 feet in width. Adjacent to the plumasite the zone consists of a belt of brown mica, variable in width, which passes laterally into a proportionally wider belt of massive or foliated talc. The mica is brownish, with weak to moderate pleochroism, and an axial angle of 2° to 20° or 30° , and considered to consist of both biotite and phlogopite.¹⁴ Irregular or lenticular patches of the mica occur as xenoliths in the plumasite. Isolated patches of the talc may occur in the serpentine. In the reaction between the pegmatitic solutions and the serpentine the serpentine received an addition of silica, alumina, potash and fluorine to form the

¹⁴ More probably vermiculite.

zones of biotite and talc, resulting in the impoverishment of these constituents in the dike which crystallized into an aggregate of oligoclase, corundum, and margarite, with occasional tourmaline.

TABLE I. ANALYSIS OF OLIOGCLASE.

	A	B
SiO ₂	61.36	62.76
Al ₂ O ₃	22.97	21.95
CaO.....	5.38	2.68
Na ₂ O.....	8.08	10.31
K ₂ O.....	...	1.08
H ₂ O.....	1.72	0.29
Sp. gr.....	99.51	99.07
	2.633	2.628

A. *Oligoclase*, Spanish Peak, Plumas County, Calif.; Lawson, loc. cit., analysis by J. Newfield.

B. *Oligoclase*, Mosso Santa Maria, Biella, Italy; A. Cossa.¹⁵

PENNSYLVANIA AND MARYLAND ALBITITES.

Albitite has long been quarried for feldspar in the serpentine area along the Pennsylvania-Maryland line, which includes southern Lancaster and Chester counties, Pennsylvania, and Cecil County, Maryland.

The geology of part of the district has been described by Bascom,¹⁶ and the principal quarries by Hopkins¹⁷ and Bastin.¹⁸

The district is underlain by an igneous complex, to the north of which lies a mica gneiss thoroughly injected by a fine grained granite. The igneous rocks form a batholithic mass, in which the following interesting series is exhibited in passing from the south-east to the northwestern part of the district: biotite granodiorite, hornblende granodiorite, quartz-biotite-hornblende gabbro, quartz-hornblende gabbro, hornblende-norite and quartz-norite, norite, pyroxenite, and peridotite. All are more or less metamorphosed, the granodiorites assuming a gneissic structure, while the peridotite is usually altered to serpentine.

The more important albitite dikes are limited to the largest serpentine mass which lies along the Pennsylvania-Maryland line

¹⁵ A. Cossa. *Ricerche chimice e microscopiche su rocce e minerali d'Italia*, Feldispathe corindonifero della Biellese. Torino, 1881, 65.

¹⁶ Maryland Geolog. Survey, Cecil County, 83-148, 1902.

¹⁷ Ann. Rep. Penna. State College, 1898-99: 7-20.

¹⁸ U. S. Geol. Surv. Bull. 420: 63-77, 1910.

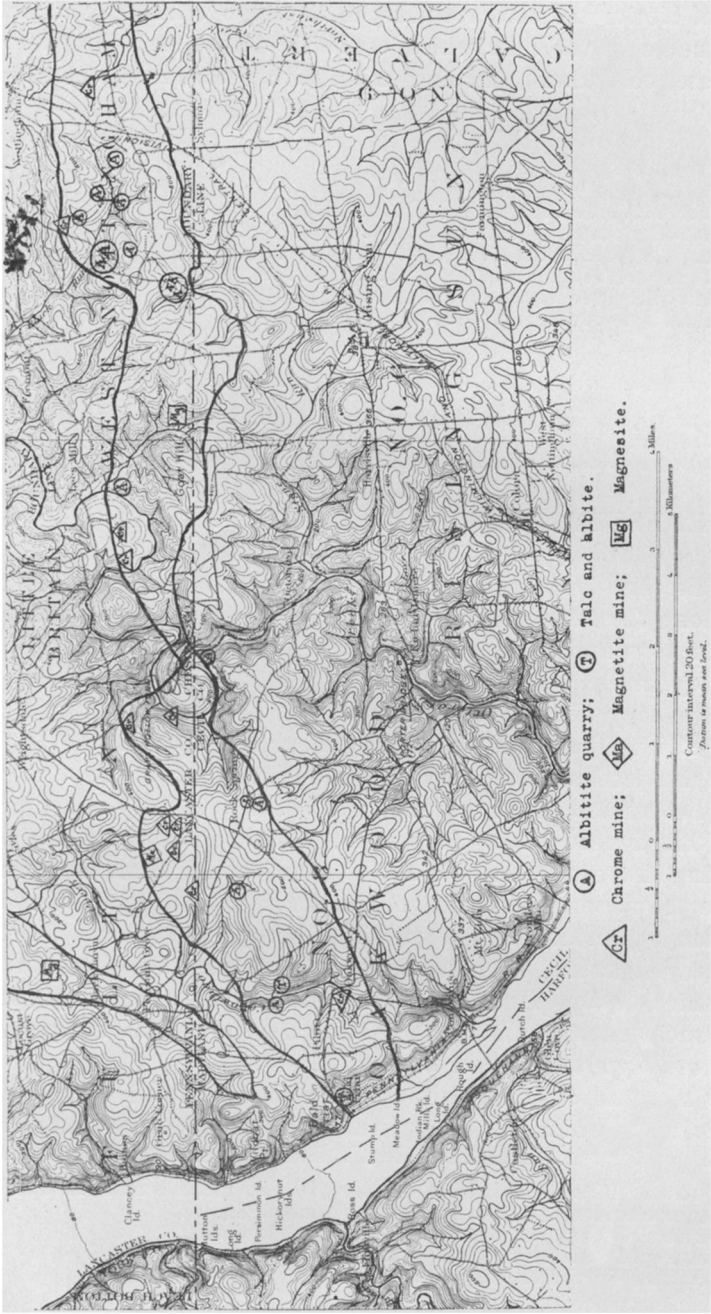


Fig. 1.—Albitite quarries of the Havre de Grace quadrangle, Lancaster and Chester Counties, Penna., and Cecil Co., Md. The heavy black lines mark the boundaries of the principal meta-peridotite (serpentine) areas, to the north of which lie mica schists. The areas are bounded on the south by norite.



Fig. 2.—Albitite and plumasite occurrences of the West Chester quadrangle, Chester County, Penna. B, Brinton's serpentine quarry, containing veins of albitite; Co. abandoned corundum mines in plumasite near Unionville.

(fig. 1). Small irregular dikes occur also in Brinton's serpentine quarries, three miles south of West Chester (fig. 2). Extensive quarries lie west and northwest of Sylmar in Chester County, and southeast of Rock Springs, and northeast of Pilot, Cecil County. In two cases, east of Bald Friar, and a mile northeast of Pilot, Cecil County, quarries have produced commercially both albite and talc. But two quarries are at present worked: Wiant's quarry three-quarters of a mile northeast of Pilot, and Garrison's quarry, three-quarters of a mile east of Rock Springs, Cecil County. The others are abandoned and filled with water, but their size gives evidence of the great quantity of albite which they formerly produced.

The albitite dikes range in size from a few inches in width, such as at Brinton's quarry, south of West Chester (fig. 2), to great masses four or five hundred feet in length, and more than a hundred feet in width, such as were quarried at the Rock Springs quarry, and at the Sparvetta, Keystone, and Brandywine quarries, one and a half miles west of Sylmar, and at Campbell's quarry, two miles northwest of Sylmar.

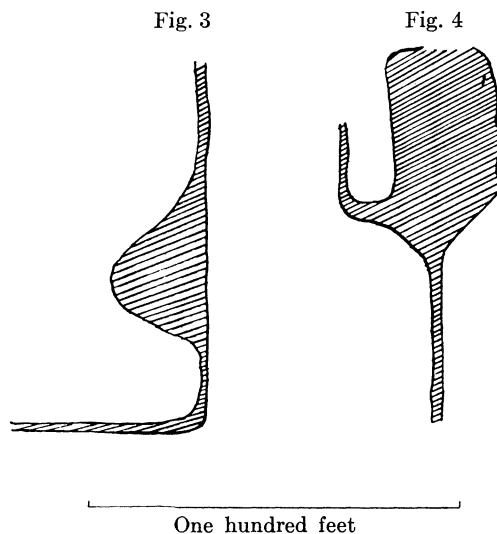


Fig. 3.—Horizontal section of an albitite dike quarried one and a quarter miles northwest of Sylmar, Chester County, Pennsylvania.

Fig. 4.—Horizontal section of an albitite dike quarried two miles northwest of Sylmar.

As is characteristic of pegmatites in general, the albitite dikes are exceedingly irregular, pinching and swelling, and very frequently bifurcating. Examples of the irregularities are shown in fig. 3 and fig. 4.

The albitites consist almost entirely of granular white, yellowish, or bluish gray, translucent albite.¹⁹ Most of the albite is untwinned,—a peculiarity noted above as being shown by the albite of the California albitite, and in the oligoclase of the Natal plumasite. A yellowish-white untwinned albite from Campbell's quarry, two miles northwest of Sylmar gave the following indices of refraction upon immersion, indicating a quite pure albite: $\alpha = 1.526$, $\beta = 1.530$, $\gamma = 1.536$, $\text{all} = 0.0005$. A granular grayish white albite from the vicinity of the Line Pit (probably from the present site of Garrison's quarry, three-quarters of a mile west of Rock Springs) was analyzed by Brush²⁰ with the following results:

TABLE 2. ANALYSIS OF ALBITE.

Granular, grayish-white; near the Lancaster County chrome mines. Analysis by Brush.

SiO ₂	66.65
Al ₂ O ₃	20.79
MgO.....	0.52
CaO.....	2.05
Na ₂ O.....	9.36
	99.37
Sp. gr.....	2.619

Quartz is conspicuous by its absence, having been noted at but one locality, a quarry north of Black Run, one and a half miles northwest of Sylmar, where it occurs with much muscovite and anorthoclase (fig. 7). The most frequent accessory minerals are hornblende and biotite. Hornblende forms minute radiating groups while biotite occurs in minute crystals, scattered through the albite, at times occurring locally in large amount. Tourmaline is abundant in the albitite of Brinton's quarry, and molybdenite has been found in the quarries northwest of Sylmar. Actinolite sometimes occurs in beautiful greenish radiations through the albite, especially near the margins of the dikes. The albitite of Wiant's quarry, three-quarters of a mile northeast of Pilot, Cecil County, is filled with miarolitic cavities which are lined with minute, color-

¹⁹ Called "leelite" in some of the earlier lists of Pennsylvania minerals.

²⁰ Am. J. Sci. (2), 8: 390, 1849.

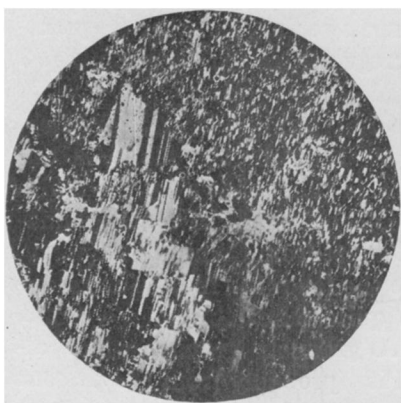


Fig. 5

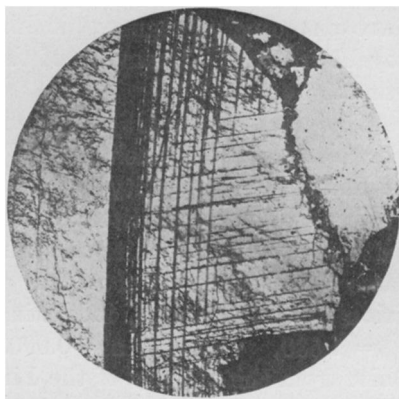


Fig. 6

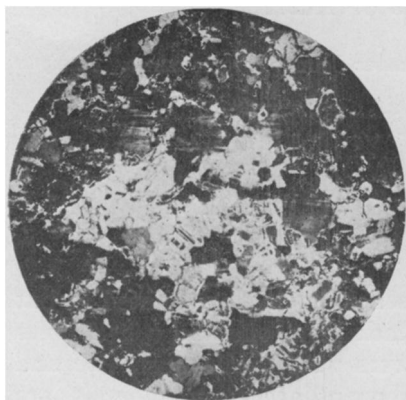


Fig. 7

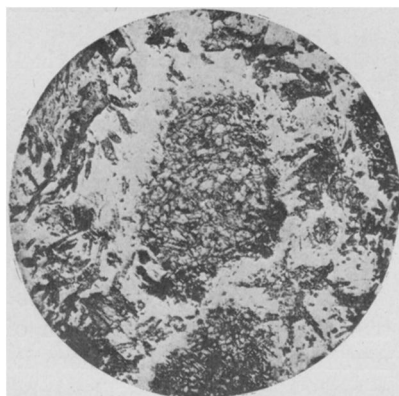


Fig. 8

Fig. 5.—Albite, Garrison's quarry, west of Rock Springs, Cecil County, Maryland. Crossed nicols, x 15.

Fig. 6.—Albite, showing both albite and pericline twinning. One mile southwest of Nottingham, Chester County. Crossed nicols, x 15.

Fig. 7.—Albite (black), anorthoclase (twinned), and quartz (white), one and a half miles northwest of Sylmar, Chester County, Penna. Crossed nicols, x 15.

Fig. 8.—Aggregates of zoisite (gray in center), in serpentine (white groundmass) through which are dispersed needles and blades of actinolite (dark). One and a half miles northwest of Sylmar. Plain light, x 15.

less albite crystals. Minute, transparent, greenish, highly modified beryl crystals occur rarely implanted on the albite, while not infrequently the rest of the cavity is filled with matted masses of dark greenish actinolite needles. Occasionally a peculiar green and white porphyritic rock occurs near the margin of the dikes, especially in the Sylmar district. Examination of thin sections of of this material shows the phenocrysts to be aggregates of zoisite in a groundmass of serpentine, and actinolite needles, (fig. 8). Such an association in which the zoisite was pink in color has been briefly described by Wherry.²¹

Adjacent to the albitite dikes are usually three distinct zones of minerals formed by the reaction of the pegmatitic solutions with the serpentine walls. In passing from the albitite to the serpentine their order is: vermiculite, actinolite with more or less talc, and talc—beyond which lies the serpentine (fig. 9).

The vermiculite zone consists of brown scaly vermiculite, representing a weathered biotite. Analyses of the variety jefferisite from Brinton's quarry, Chester county, are given below. Masses of vermiculite may occur in the albitite. The actinolite zone, which is thinner than others, consists of greenish radiating crystals of actinolite with more or less talc. The talc zone consists of silvery white to light greenish, massive or foliated talc, in which are usually disseminated many minute octahedral crystals of magnetite.

It will be observed that there is a gradual increase of magnesia and water in passing from the albitite to the serpentine. From this it seems probable that the peridotite had been serpentinized prior to the intrusion of the albitite, which had the effect of partially dehydrating the serpentine in the vicinity of the intruded mass. In the formation of the biotite (now vermiculite), actinolite, and talc zones, the pegmatitic solutions were more or less depleted of silica, alumina, lime, potash, and fluorine. The potash, fluorine, and alumina went to form the biotite zone, magnesia and perhaps iron being furnished by the serpentine. Most of the silica was used in silicating the serpentine to actinolite and talc, the physico-chemical conditions being such as to cause the formation of hydroxy-silicates. The result was that the original pegmatitic solutions, which under normal circumstances would have crystallized into a rock composed of quartz, microcline, albite or oligoclase, muscovite

²¹ Edgar T. Wherry, Some Minerals from Sylmar, Pennsylvania, *Am. Min.*, 3: 47, 1918.

and biotite, lost practically everything but the constituents of albite, and consequently solidified to a rock consisting almost wholly of this mineral.

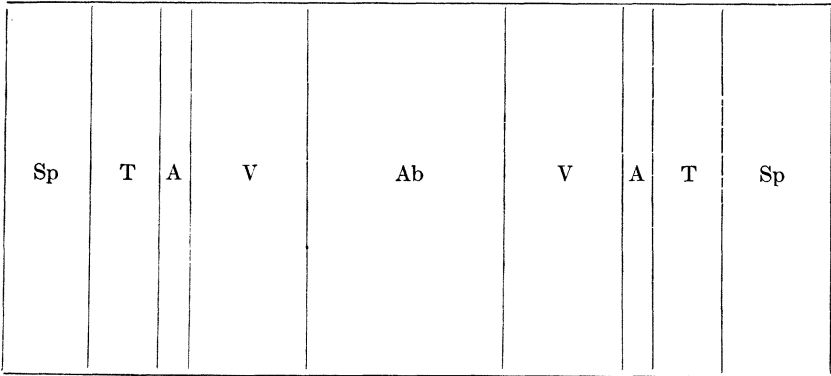


Fig. 9.—Generalized diagram of the contact phenomena shown by the Pennsylvania and Maryland albitite dikes. Ab = albite; V = vermiculite (altered biotite); A = actinolite, with more or less talc; T = talc; Sp = serpentine.

TABLE 3. ANALYSIS OF JEFFERISITE, BRINTON’S QUARRY, CHESTER COUNTY, Pa.

A. Clarke and Schneider;²² B. Koenig;²³ C. Chatard.²⁴ An earlier but erroneous analysis by Brush is omitted.²⁵

	A	B	C
SiO ₂	34.20	33.35	34.40
Al ₂ O ₃	16.58	17.78	16.63
Fe ₂ O ₃	7.41	7.32	8.00
FeO.....	1.13	2.11	(2.11) ²⁴
MgO.....	20.41	19.26	19.30
H ₂ O.....	21.14	19.87	19.03
	100.87	99.69	99.47

²² Am. J. Sci. (3), 40: 452, 1890.
²³ Proc. Am. Phil. Soc., 13: 392, 1873.
²⁴ Am. J. Sci. (2), 31: 370, 1861. Previous to this the mineral had been known to collectors under the name of phlogopite.
²⁵ Taken from Koenig’s determination.



Fig. 10.—Albitite and plumasite occurrences of the Chester quadrangle, Delaware County, Penna. A, Albitite occurrences; Co, abandoned corundum mines in plumasite.

PENNSYLVANIA PLUMASITES.²⁶

Plumasites or corundum-bearing pegmatites occur in Pennsylvania at the following localities: Morgan Station and Black Horse in Delaware County, (fig. 10), and near Unionville, Chester County (fig. 2). All form intrusive masses in serpentine, or at the contact of serpentine and gneiss.

The geology of the region has been described by Rogers,²⁷ Frazer and Hall,²⁸ Rand,²⁹ Bascom³⁰ and others. The area is underlain by Precambrian gneisses and schists into which have been intruded bodies of granite, gabbro, peridotite and pyroxenite. The basal or Baltimore gneiss is a banded quartz-feldspar rock with massive granitic facies. Overlying this is the Wissahickon mica gneiss, a schistose quartz-feldspar rock with an excess of biotite or muscovite. The peridotites and pyroxenites, which are genetically related to the gabbros, in most cases have been hydrated to serpentine.

MORGAN STATION (VILLAGE GREEN.) This locality is situated on a very small patch of serpentine intrusive in Wissahickon gneiss one-quarter mile south of Morgan Station, Aston township (fig. 10). Large bronzy brown corundum crystals were found sheathed with white pearly margarite.³¹

BLACK HORSE, MIDDLETOWN TOWNSHIP. An old corundum mine was formerly situated in a large area of serpentine about one-quarter mile south of Black Horse, on the west side of the road to Elwyn (fig. 10). Many loose crystals of corundum were found in the soil in the vicinity of the pit, and elsewhere in the township. One half mile to the west are exposed granite gneisses. The corundum in slender bipyramidal crystals, of a white to brown color, often asteriated,³² was found in a granular white albite-oligoclase.

²⁶ As it has been stated that corundum was first found in America in Laurens County, S. C., in 1819, it is desirable to point out an earlier discovery of this mineral at Chestnut Hill, Philadelphia: Adam Seybert, Adamantine spar and basaltes, *Medical Repository*, 3: 202, 1800; also J. C. Delam  therie, *J. de Phys.* (53), 9: 404-405, 1801.

²⁷ Henry D. Rogers, *Geology of Pennsylvania*, 1858.

²⁸ Second Geological Survey of Penna., Reports C4 and C5, 1883 and 1885.

²⁹ *Proc. Acad. Nat. Sci., Phila.*, 1900: 160-338.

³⁰ *Bull. Geol. Soc. America*, 16: 289-328, 1905; *U. S. Geol. Surv. Folio* 162, 1909.

³¹ *Am. J. Sci.* (2), 379-380, 1849.

³² *Proc. Am. Phil. Soc.*, 13: 361-406, 1873; *Ibid.*, 20: 381-404, 1882; Joseph Willcox, Second Geol. Surv. Penna., Rep. C4: 346-354, 1883.

UNIONVILLE, CHESTER COUNTY.³³ The Unionville corundum mines, now abandoned, are situated in Newlin township, respectively one and a half and two miles northeast of Unionville (fig. 2), at the contact of serpentine and mica gneiss. Many boulders of corundum were obtained in the fields by the farmers who systematically dropped a crow-bar in the soil in the trail of the plow.

At the pits one and a half miles northeast of Unionville the corundum was found in a rock consisting of granular white albite, corundum, black tourmaline, margarite, and euphyllite—a basic sodium and potassium mica. The corundum occurred in white or grayish crystals. Zoisite was abundant, and occasionally black octahedra of spinel were obtained. Adjacent to the vein the following minerals were noted: talc in white foliated masses and greenish actinolite with much dark green chlorite.

At the mine one-half mile north of the preceding one a vein of corundum and margarite seven feet thick was uncovered, which was separated from the serpentine by a zone of foliated talc. In this a vein of fawn-colored diaspore measuring three by two feet in length and width, and two inches in thickness was discovered, some of the crystals of which were two inches long.³⁴ The corundum was white, brownish gray, to bluish. Crystals not infrequently were sheathed with margarite or damourite. Margarite formed in yellowish or pinkish foliated masses, or secondary aggregates of scales with cores of corundum. Associated with the margarite were honey-yellow or fawn colored laminated masses of diaspore, occasionally in perfect spendent crystals up to two inches in length. Beautiful translucent bluish or greenish prismatic crystals of tourmaline penetrate the diaspore. The association is such as to indicate the order of crystallization: tourmaline, diaspore, margarite. Jefferisite (vermiculite) is found in large yellowish green plates.

The plagioclase at the Unionville mines varies from white albite to yellowish striated oligoclase. Analyses of these are given below.

³³ H. D. Rogers, *Geology of Pennsylvania*, I, 1858, 170. Joseph Willcox, *Sec. Geol. Surv. Penna. Rep.*, C4: 346, 1883. Joseph Leidy, *Proc. Acad. Nat. Sci. Phila.*, 1872: 238–239. Frederick A. Genth, *Proc. Am. Phil. Soc.*, 13: 361–406, 1873; 20: 381–404, 1882. The statement “about one mile from Unionville on the Kennett Square road” means from the upper mine, and not the village of Unionville.

³⁴ Isaac Lea, *Proc. Acad. Nat. Sci. Phila.*, 19: 44–45, 1867.

TABLE 3. ANALYSES OF ALBITE AND OLIGOCLEASE, UNIONVILLE, CHESTER COUNTY, PA.

A. Albite, white; mean of two analyses. J. L. Smith and George J. Brush, *Am. J. Sci.* (2), 15: 211, 1853.

B. Albite, white, crystalline. Martin H. Boye, *Proc. Am. Phil. Soc.* 2: 150, 1841.

C. Albite, white, crystalline; analysis by Weld. Benjamin Silliman, Jr., *Am. J. Sci.* (2), 8: 377-394, 1849.

D. Oligoclase, brownish-white; analysis by Thomas M. Chatard. Frederick A. Genth, *Proc. Am. Phil. Soc.*, 13: 361-406, 1873.

	A	B	C	D
SiO ₂	64.27	67.72	66.86	59.35
Al ₂ O ₃	21.21	20.54	21.89	24.16
Fe ₂ O ₃	tr.	tr.	....	0.61
MgO.....	0.58	0.34	0.48	0.34
CaO.....	0.81	0.78	1.78	3.08
Na ₂ O.....	10.94	10.65	8.78	7.22
K ₂ O.....	1.36	0.16	....	3.78
Ignition.....	1.08	....	0.48	1.96
Sp. gr.....	100.25	100.19	100.27	100.50
	2.61	2.612		

LOCALITIES OF PLUMASITE IN OTHER STATES.

PELHAM, MASSACHUSETTS: The occurrence of corundum and its associated minerals at Pelham, Mass. has been described by Emerson.³⁵ The locality is an asbestos mine, one mile southwest of Mount Lincoln, Pelham township, where a great block of black saxonite is enclosed in Pelham granite gneiss.

The saxonite is a fine granular dark gray rock composed of colorless enstatite darkened by abundant chromite and magnetite, and containing porphyritic plates of bronzy enstatite. Between the Pelham granite gneiss and the saxonite a thick contact "reaction rim" has been developed. The granite gneiss is a light gray rock consisting of a granular mixture of quartz, microcline, streaked with biotite scales and epidote grains. Near the contact the granite is more massive, less biotitic and quartzose, and grades into a layer of snow-white, fine grained anorthite containing some andesine crystals, and much disseminated tourmaline, rutile, zircon, and allanite. This layer passes into an interrupted layer of black massive tourmaline in many places two feet thick, at times containing some large imperfect crystals of the mineral, with small

³⁵ U. S. Geol. Surv. Monograph, 29: 47-55, 1898; U. S. Geol. Surv. Bull., 597, 215-216, 1917. See also Earl V. Shannon, *Am. Min.*, 4: 37-39, 1919.

crystals of apatite and zoisite. The last zone is composed of coarsely matted reddish-brown biotite from four inches to four feet thick containing many nodules of dark green fibrous actinolite and large nodules and crystals of corundum. Beyond this lies the saxonite which for a distance of three to twelve feet contains a network of veins of colorless, fibrous anthophyllite,—the asbestos for which the pit was worked.

The tourmaline, rutile, and allanite are characteristic of pegmatitic assemblages, and in this case a pegmatitic facies probably developed at the margin of the Pelham granite gneiss which reacted with the saxonite to form the interesting series of contact minerals. Beyond the contact zones siliceous solutions entered the fractured saxonite and silicated the saxonite minerals to anthophyllite.

CHESTER, MASSACHUSETTS: The Chester emery deposits have been described by Jackson,³⁶ Shepard,³⁷ and Emerson.³⁸ The Chester emery deposits occur as a series of small disconnected lenses up to sixteen feet in thickness, but averaging four feet, between the Chester hornblende schist and serpentine. The hornblende schist is a dark-green to black foliated or ligniform epidotic quartz-hornblende schist considered by Emerson to be of sedimentary origin. The hornblende schist is bordered at several places with lenticular intrusive masses of serpentine.

The emery vein consists of a mixture of chlorite and magnetite containing in abundance bronze colored crystals of corundum, and a considerable quantity of tourmaline in black crystals or stellated aggregates. In passing from the hornblende schist to the serpentine the following sequence is noted: hornblende schist, biotite layer, chloritic band with tourmaline, emery vein with various minerals, corundophilite zone, talc zone, and finally serpentine. The corundophilite zone may be wholly replaced by a white to reddish, fine grained saccharoidal oligoclase up to twelve inches in thickness.

One of the most interesting sections is that of the mine at the base of South Mountain. The serpentine on the east passes into a zone of pure, light-green, schistose or massive talc, through which are scattered remnants of serpentine from which the talc was derived. The width of this zone varied from five to fifteen feet.

³⁶ Am. J. Sci. (2) 39: 87, 1865.

³⁷ Charles U. Shepard, A description of the emery mine of Chester, Hampden County, Mass., London, 1865.

³⁸ U. S. Geol. Surv. Bull., 597: 159-161, 1917.

See also Earl V. Shannon, Am. Min., 4: 69-72, 1919.

Beyond this is the corundophilite zone³⁹ composed of plates of corundophilite 20 mm. broad, which may be wholly replaced by oligoclase. The corundophilite often penetrates the emery vein in sheets filling fissures, on which may occur in cavities fine foliated sheets of pearly margarite, and thick masses of interlaced blades and crystals of violet diaspore, frequently enclosing bright red needles of rutile, or broad plates of ilmenite.³⁹ Rarely associated with these are radiating yellowish green needles of epidote, or brown crystals of brookite. To a much later period of mineralization belong veins of specular hematite in small rosettes, pyrite, chalcopyrite, calcite, and aragonite.

It will be seen that the mineralogy of this deposit is quite complex. However, the presence of such minerals as tourmaline, oligoclase, rutile, brookite, etc., the evidence of reaction with the serpentine, and the features resembling the plumasites described above, all indicate that this deposit probably owes its origin largely to the desilication of a granitic pegmatite intruded along the contact of the hornblende schist and serpentine.

GEORGIA: The Georgia corundum deposits have been described by Francis P. King.⁴⁰ All of the deposits occur in ultrabasic rocks forming intrusive masses in the gneisses and schists. The veins vary in form, and are from one to twelve feet in width. The following four types were recognized by King: (a) lime-soda feldspar with quartz and phlogopite or vermiculite, (b) lime-soda feldspar with actinolite; (c) a coarse-grained aggregate of lime-soda feldspar, black hornblende, and margarite; (d) a massive vein made up of light grass-green amphibole ("smaragdite"), lime-soda feldspar, and a little chromite. All these types have walls of compact, scaly chlorite, which quite frequently contains corundum. The second type (b) is rare, and the corundum crystals usually possess a sheathing of secondary margarite. The third type (c) is more common than (b), but it differs from the first two in its massive, pegmatitic character. The fourth type (d) is very rare, being known only at the Bell Creek mine, Towns County, and in Clay County, North Carolina. The rock is made up of a beautiful grass-green bladed smaragdite, and feldspar, through which are scattered pink and ruby-red corundum.

At the Hog Creek mine, Town's County, a boulder of zoisite en-

³⁹ Known to the old miners as the "fringe rock."

⁴⁰ Francis P. King, Geological Survey of Georgia, Bull., 2, 1894.

cased in finely fibrous actinolite was found. The most important mine, however, was that at Laurel Creek, Rabun County, which occurred near the contact of peridotite and gneiss.

NORTH CAROLINA: The corundum deposits of North Carolina have been described in detail by Joseph Hyde Pratt and J. Volney Lewis.⁴¹ They occur largely in areas of peridotites and pyroxenites intrusive in the gneisses and schists in the mountain belt extending from Georgia through Clay, Macon, Transylvania, Jackson, Haywood, Buncombe, Madison, Yancey, and Mitchell Counties. The peridotites are usually dunite or saxonite, but secondary serpentine, talc, chlorite, and amphibole schists occur.

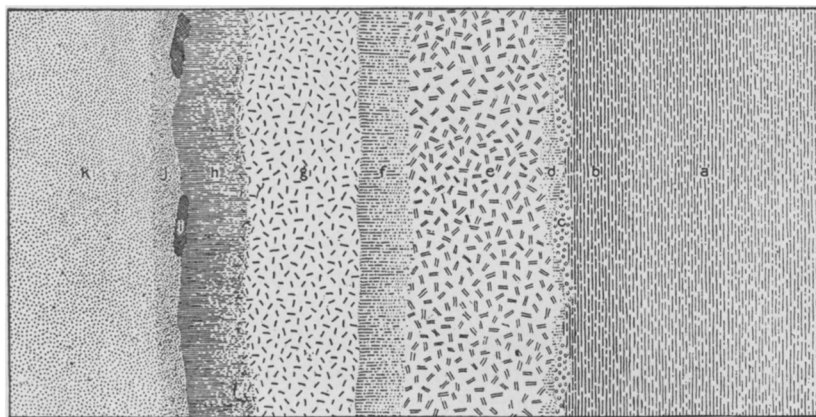


Fig. 11.—Ideal section of a border vein of corundum at the Corundum Hill mine, Macon County, N. C. (Pratt and Lewis); (a) gneiss, hornblende or micaceous, unaltered; (b) gneiss, decomposed; (c) yellowish vermiculites, often merging into (d), and sometimes absent; (d) green chlorites of varying thickness; (e) the corundum vein consisting of chlorite and corundum, often with some vermiculites; (f) green chlorites; (g) enstatite, in places hard and compact, usually merging into (h); (h) talcose rock, usually fibrous; (i) a seam of yellowish clay often carrying masses of quartz and chalcedony, sometimes absent; (j) more or less altered dunite; (k) fresh dunite. An important variation is the development of a zone of corundum-bearing plagioclase either in the corundum-bearing zone of chlorites or vermiculites (e) or entirely replacing this zone.

Two types of corundum veins were recognized by Pratt and Lewis: the peripheral or border veins at the contact of peridotite and gneiss, and interior veins which occurred wholly within the peri-

⁴¹ J. Volney Lewis, N. C. Geol. Surv. Bull., 11, 1896. Joseph Hyde Pratt, U. S. Geol. Surv. Bull., 180, 1901; and 269, 1906. Joseph Hyde Pratt and J. Volney Lewis, North Carolina Geol. Surv. I, 1905. Am. J. Sci. (4) 8: 227-231, 1899.

dotite. In all cases interesting series of contact zones are exhibited (figs. 11 to 13).

Important deposits were worked in Clay County near Elf on Shooting Creek, on Chunk Gal Mountain, and at Buck Creek. At the Buck Creek or Cullakenee mine, the corundum occurred as grayish-white, bluish, or pink crystals with a deep green smaragdite, and a white granular plagioclase, ranging in composition from andesine to anorthite. Associated with these were grayish columnar masses of zoisite, and lamellar crystals of margarite. Analyses of the plagioclase are given below.

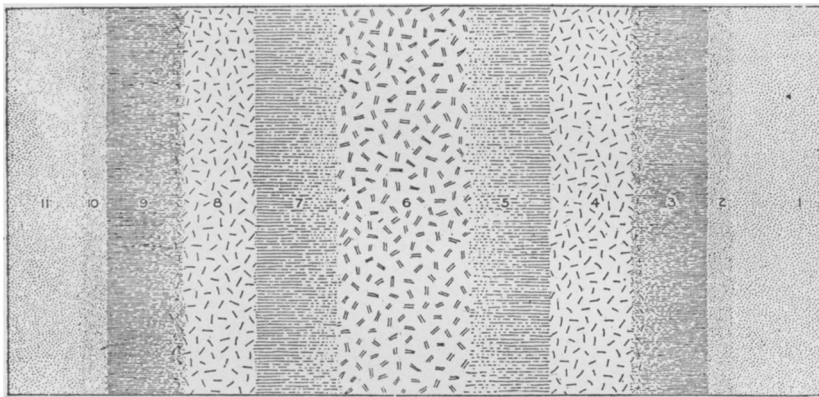


Fig. 12.—Ideal cross-section of an interior vein of corundum at the Corundum Hill mine, Macon County, N. C. (Pratt and Lewis); (1 and 11) normal dunite; (2 and 10) somewhat friable and discolored dunite; (3 and 9) fibrous talc; (4 and 8) grayish, somewhat fibrous, enstatite; (5 and 7) green chlorites; (6) central corundum-bearing zone consisting of chlorites, corundum, and spinel. An important variation is the development of a zone of corundum-bearing plagioclase either in zone (6) or entirely replacing it.

At this mine two zeolites, wellsite and chabazite, were found in veins in the feldspar.

One of the most important mines was the Corundum Hill or Cullasaja mine, seven miles northeast of Franklin, Macon County. The veins were of both the border and interior types (figs. 11 and 12). An analysis of oligoclase from this locality is given below. In addition, large masses of black tourmaline containing corundum were found, and very rarely margarite, and minute crystals of diaspore.

At the Cowee Valley, Macon County, small ruby crystals have been found enclosing rhodolite, a garnet of the composition: $3\text{Mg}_3\text{Al}_2(\text{SiO}_4)_3:\text{Fe}_3\text{Al}_2(\text{SiO}_4)_3$.

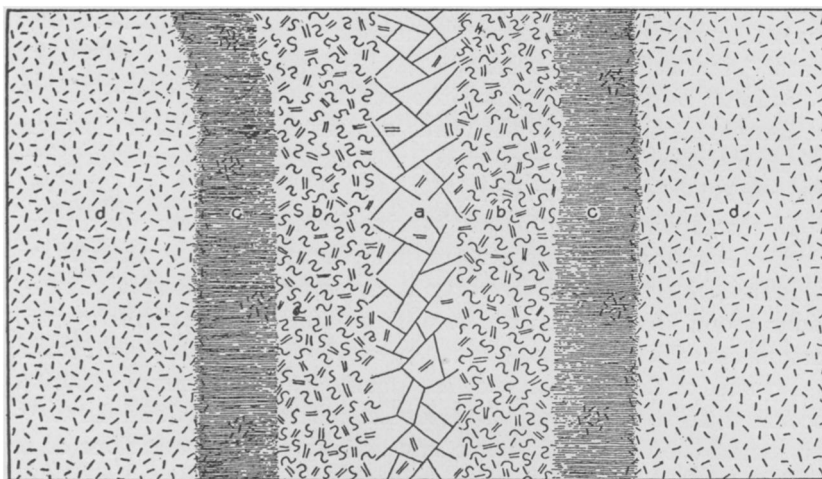


Fig. 13.—Ideal vertical section of corundum in amphibolite at Hunters, Iredell County, N. C. (Pratt and Lewis); (a) a feldspar vein more or less altered to kaolin and often bearing corundum; (b) vermiculite zones carrying corundum; (c) radiating sheaths of actinolite enclosing some amphibolite; (d) amphibolite often reduced to a mass of ocherous clay containing needles of hornblende and scales of vermiculite.

TABLE 5. ANALYSES OF THE PLAGIOCLASE FELDSPARS OF THE NORTH CAROLINA CORUNDUM VEINS.

A. Oligoclase. Corundum Hill mine, Macon County, N. C. H. M. Keller, U. S. Geol. Surv. Bull., 74, p. 55.

B. Andesine. Buck Creek mine, Clay County, N. C. Snow-white to bluish-white masses, striated. G. A. Koenig, Proc. Am. Phil. Soc., 13: 375, 1873.

C. Andesine. Buck Creek mine, Clay County, N. C. T. M. Chatard, Proc. Am. Phil. Soc., 13: 375, 1873.

D. Labradorite. Buck Creek mine, Clay County, N. C. White lustrous cleavage masses. W. H. Jarden, Bull. U. S. Geol. Surv., 74, p. 54.

	A	B	C	D
SiO ₂	63.32	57.29	58.41	55.61
Al ₂ O ₃	35.19	26.52	25.93	26.90
Fe ₂ O ₃.....	....	0.21	0.38	....
MgO.....	....	0.15	0.18	....
CaO.....	5.01	7.80	5.82	9.60
Na ₂ O.....	8.02	6.75	6.45	6.97
K ₂ O.....	0.25	0.33	2.10	0.55
Ignition.....	....	1.43	0.93	0.35
Sp. gr.....	101.79	100.48	100.20	99.98
	....	2.611	2.610	....

The origin of the North Carolina deposits has been a much discussed question. The contact zones were described early by Shepard,⁴² Chatard,⁴³ and others.

Julien,⁴⁴ although regarding the dunite beds as metamorphosed sediments, believed that the veins originated by the introduction of deep seated solutions of soda and alumina into fissures during the period of metamorphism.

Chatard pointed out the progressive increase in magnesia as the dunite is approached and a gradual decrease in the amount of alumina. He regarded the corundum veins as the result of alterations along the contact of aluminous-alkaline silicate rocks and magnesian-silicate rocks, probably effected by surface solutions.

Because of the circumstance that many of the corundum deposits occurred at the margins of peridotite masses, Pratt and Lewis⁴⁵ presented the theory of their origin as magmatic segregations of a peridotite magma. It was believed that the corundum was held in solution in the molten peridotite when it was intruded, and that the corundum was among the first minerals to crystallize out. This solidification would take place first at the outer border of the mass where it cooled first. Convection currents would tend to bring a new supply of material carrying alumina to this outer zone where it would crystallize.

Holland⁴⁶, and Teall⁴⁷, presented objections to this theory based on the rather old experiments of Morozewicz⁴⁸, which indicated that in a magma supersaturated with silica, that is, one in which the molecular ratio of Al_2O_3 to the bases CaO , K_2O , and Na_2O is more than 1: 1, the excess of silica would separate out as corundum if MgO and FeO were absent and SiO_2 were not present in an amount sufficient to form sillimanite. With the presence of MgO and FeO spinel would form, or if enough silica were present iolite (cordierite).

More recently the ternary system $\text{MgO-Al}_2\text{O}_3\text{-SiO}_2$ was studied in detail by Rankin and Merwin.⁴⁹ The results of their precise

⁴² Am. J. Sci. (3) 4: 109-114, 175-180, 1872.

⁴³ U. S. Geol. Surv. Bull., 42: 45-63, 1888.

⁴⁴ Proc. Boston Soc. Nat. Hist., 22: 141-149, 1882.

⁴⁵ Loc. cit.

⁴⁶ Mem. Geol. Surv. India, 30: 209, 1901.

⁴⁷ Proc. Geol. Assoc., 16: 72, 1899.

⁴⁸ Tschermak's Min. u. Petr. Mitth., 18: 1-90, 105-240, 1899.

⁴⁹ Am. J. Sci., (4) 45: 301-325, 1918. See also Olaf Andersen, *Ibid.*, 39: 407-454, 1915.

work indicate that corundum would not be expected as an early phase in the crystallization of a dry magma near peridotite in composition. It is clear that evidence of magmatic segregations of corundum in ultrabasic rocks is lacking.

On the other hand the presence of abundant tourmaline, much plagioclase, with garnet, zoisite, vermiculite, etc., is indicative of pegmatitic assemblages, and it is therefore more probable that these corundum veins represent granitic pegmatites which have so reacted with the wall rocks as to almost lose their identity. The contact zones are somewhat different from those of the plumasites described above, but wide variations are to be expected depending on the composition of the original pegmatitic solutions, and even more so on the character of the peridotite or pyroxenite, and on whether these had already been hydrated to serpentine. It may be noted that much magnesia was assimilated by the pegmatitic solutions with the formation of much chlorite and biotite (since altered to vermiculite) and some spinel in the corundum veins. The distinct chloritic zones are evidence of reaction with the wall rock, whereby alumina was furnished by the pegmatitic solutions, and magnesia by the peridotite. The zone of enstatite may be explained by silication of the olivine, perhaps by the reaction $\text{Mg}_2\text{SiO}_4 + \text{SiO}_2 = 2\text{MgSiO}_3$ or the mineral may have been produced by abstraction of some of the magnesia. Incidentally it is rather unusual to find enstatite rather than anthophyllite. The position of the talc zone between the dunite and the enstatite is anomalous, but it might be noted that most of the analyses of the North Carolina dunites show the presence of water, and more or less alteration to serpentine.

SUMMARY OF MINERALOGY OF DESILICATED GRANITIC PEGMATITES.

The mineralogical composition of this group depends largely on the composition of the original pegmatitic solutions, that of the wall rock (peridotite, pyroxenite, serpentine, etc.), and the degree of desilication or extent of reaction between the two. Variations in the character of the zones also occur. In some cases different periods of mineralization, some distinctly later than others, may occur. The minerals, exclusive of those occurring in the contact zone, which are more properly to be regarded as contact metamorphs of the peridotites, serpentines, etc., are listed below.

PRIMARY. *Trisilicates* (*feldspars*): albite, oligoclase, andesine, labradorite, anorthite. *Metasilicates* (*amphiboles*): actinolite, hornblende (edenite), (*miscellaneous*) beryl. *Orthosilicates* (*garnets*): almandite, rhodolite, (*boro-*) tourmaline, (*oxy-*) sillimanite, (*hydroxy-*) epidote, zoisite, allanite; (*micas*) muscovite, damourite, euphyllite, biotite, margarite; (*chlorites*) corundophilite, etc. *Hydrous metasilicates*: chabazite, wellsite. *Phosphates*: apatite. *Oxides*: corundum, spinel, diaspore, rutile, brookite, ilmenite, quartz (rare). *Sulfides*: molybdenite, pyrite.

WEATHERING PRODUCTS. *Hydrous silicates*: kaolinite, colerainite, vermiculite (jefferisite), etc. *Carbonates*: aragonite. *Hydrous oxides*: limonite.